Fisheries Research Services in association with the **Atlantic Salmon Trust**

Catch and Release: the Survival and Behaviour of Atlantic Salmon Angled and Returned to the Aberdeenshire Dee, in Spring and Early Summer

John H Webb

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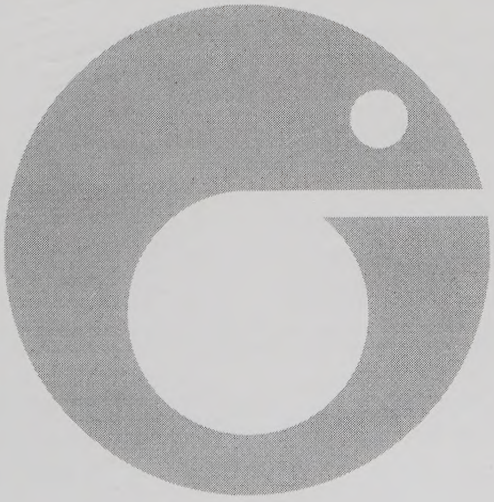

Scottish Fisheries Research Report
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Table of contents

Page

Summary 3

Introduction 4

Background 5

Methods 7

Results 8

Discussion 13

Conclusions 14

References 15

Acknowledgements 16

Summary

In 1996, 15 spring (March-April) salmon and nine early summer (May-June) salmon and an early grilse caught by anglers fishing the Aberdeenshire Dee were radio tagged and returned to the river. Fish were landed in a knotless mesh net and kept in the water during unhooking and tagging. Their survival and behaviour was monitored up to the completion of spawning later in the year using radiotracking.

Two of the released fish were captured again by anglers; one of these fish was returned to the river a second time. One fish died and contact was lost with two others. The remaining twenty-one fish (84%) were located in spawning areas in tributary streams and in the main river. The distribution and behaviour of the tracked fish at spawning was consistent with that observed in previous studies in that fish caught earlier in the year spawned higher in the river system than those caught later in the season.

The results of this study show that if fresh-run spring and early summer salmon are returned to the river by anglers many will survive to spawn. Catch and release can therefore be effective as a conservation measure.

Introduction

The last ten years has seen increasing concern about the decline in the numbers of Atlantic salmon and sea trout returning to UK rivers (Anon, 1997). Over the same period, fishery managers have become aware of the need to protect the level of egg deposition by various stock components of fish which return and spawn in their rivers. Consequently, on many rivers, management action is becoming increasingly focused on efforts to ensure the maintenance of adult escapement at levels where there are sufficient numbers of eggs spawned each year to stock all juvenile rearing habitats. If spawner numbers are allowed to fall below certain limits, then the production of smolts will probably begin to fall - leading perhaps to further reduction in the subsequent numbers of adult returns.

Against this background, the options for fishery managers are restricted. Increasingly, efforts are directed towards reducing rod and net fishing mortality on stocks before spawning. There is growing interest in catch and release fishing for both salmon (Walker and Walker,1991; Anon, 1994; NASCO, 1994; NRA, 1995; DSFIA, 1995) and sea trout (SOAEFD, 1996) as either a voluntary or mandatory management measure.

Catch and release is one of the ways in which economically important sport fisheries can continue to operate whilst reducing the impact on subsequent levels of egg deposition. Crucially, it allows the continuation of angling activity where it might be otherwise necessary to introduce more restrictive management measures. Angling activity and the revenue it generates is very important to the economy of many remote regions of the UK and elsewhere, providing an important source or employment and revenue. Furthermore, in Scotland, conservation policies that allow the continuation of angling ensure sources of rental income to fishery owners. This in turn, provides funds to pay assessments levied by local District Salmon Fishery Boards to discharge their statutory management duties.

The catch and release of salmon is not a new concept. Many anglers are quite used to returning fish alive during the fishing season at different stages of their lives. The most common examples are parr, smolts, kelts and coloured or gravid adult fish. In Atlantic Canada, for example, the return of all salmon of 63 cm or more has been required in all provinces (except Quebec) since 1984. Since 1992, anglers fishing in the state of Maine may only retain one salmon per season and other fish caught during the season have to be returned (NASCO, 1994). Catch and release is also becoming increasingly common in rivers in Scandinavia and in the rivers of the Kola peninsula in Northern Russia (NASCO, 1994).

In Scotland and the much of the rest of the UK, cultural and economic pressures have in the past meant that many anglers are reluctant to return clean, silver salmon to the river alive. Rod-caught salmon are usually killed for consumption and may be sold to defray fishing costs (Walker and Walker, 1991). Furthermore, many anglers tend to voice the opinion that the introduction of a catch and release policy that includes fresh run spring salmon may be futile as the fish may not survive to spawning.

To be a useful management tool, the adoption of catch and release for the conservation and enhancement of wild salmon stocks necessitates that the majority of the fish that are returned by anglers must survive without a substantial reduction in fitness (NASCO, 1994; NRA, 1995; DSFIA, 1995). This study was initiated to examine the survival and behaviour in the period between release and spawning. With the use of radio tagging, the fortunes of fish returned to the river by anglers fishing on the River Dee were followed through to spawning.

Background

The Aberdeenshire Dee

The Aberdeenshire Dee is one of the largest and most productive salmon rivers in Scotland. It drains an area of approximately 2,100 km^2 and rises at an altitude of approximately 1,200 m above sea level. It flows 140 km eastwards and enters the North Sea at Aberdeen.

The river has an alpine flow regime, with melting snow in the mountains that surround its headwaters being an important supply of water during the spring and early summer months. The average daily flow as measured at the lowest gauging station is 45.6 m^3 sec^{-1}. The lowest mean daily flow was recorded in August 1976 (3.7 m^3 sec^{-1}) and the highest discharges are estimated to be over 1000 m^3 sec^{-1} (Warren, 1985). A map of the Dee and its main tributaries and fisheries described in the study is shown in Figure 1.

The River Dee's salmon and fisheries

The Dee's salmon populations and its fisheries have been described in detail by Shearer (1985) and Webb (1995a). The river has an unrivalled reputation as a early salmon fishing river. Between 1952 and 1992 the Dee's rod fishery yielded an average 39% of the total reported Scottish catch of multi-sea winter salmon (MSW) salmon landed before the end of April (DSFIA, 1994). However, despite this distinction, the Dee like many of the other larger rivers on the east coast of Scotland has runs of salmon over the whole year (Menzies, 1921; Menzies and Macfarlane, 1924; 1931; Waddington, 1947; Shearer, 1992).

The river generates three main runs of fish. These are the spring and summer runs of MSW and the summer runs of grilse (1SW). Neverthe-

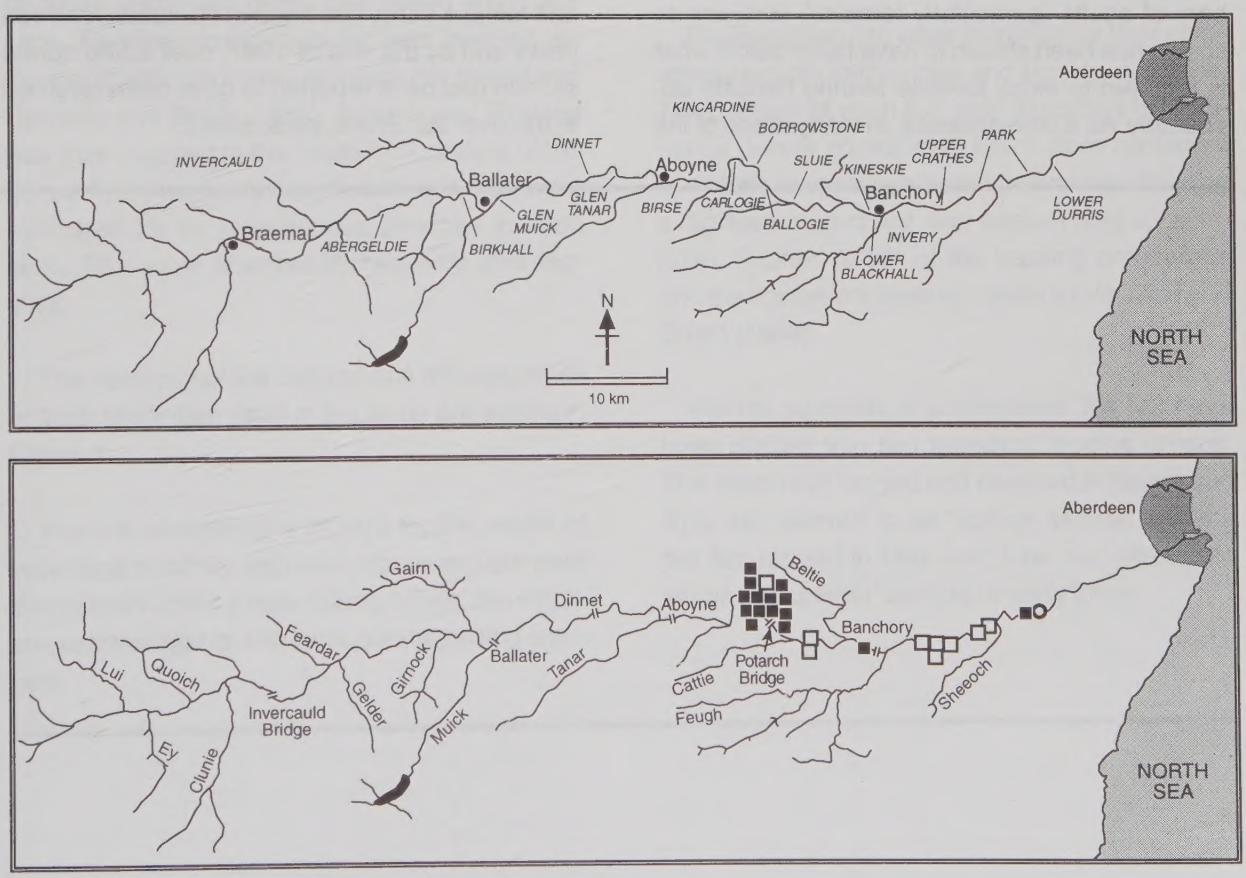

Figure 1.
The River Dee catchment showing the main tributaries, towns and angling beats mentioned in the study. The positions of the capture and release points of the spring salmon (■), summer salmon (□) and early grilse (○) used in the study are also shown.

less, its historical capacity to produce large numbers of very early running salmon is unique and particularly valuable (Webb, 1995a).

Recent fishery performance and conservation action by local management authorities and interests

The last 8-10 years has seen a rapid and more or less sustained reduction in the performance of nearly all of the Dee's angling fisheries that operate during the spring months (Youngson, 1995). This pattern has been reflected in the numbers of salmon returning to spawning tributaries in the upper reaches of the river - the area of the Dee system where the early running salmon are generated (Hawkins and Smith, 1986; Laughton and Smith, 1992; Webb, 1995a).

Together, these observations suggest a significant reduction in the numbers of early running "spring' salmon returning to the river since the mid-eighties. Indeed, in some nursery areas, the numbers of adults (particularly females) surviving to spawn has been shown to have fallen below what is required to stock juvenile rearing habitats adequately. As a consequence, in many areas of the upper reaches of the Dee, the production of young salmon is now thought to be limited by periodic shortfalls in egg deposition (eg, see DDSFB, 1996; McLaren *et al*, 1996).

The situation on the Dee is probably not unique. Many other rivers in Scotland and elsewhere have seen a broadly similar decline in spring catches (SAC, 1994; Youngson, 1995; SSSTF 1997). However, in contrast to many other rivers, the Dee fisheries have relied heavily on MSW fish that enter the river before the end of June.

In the spring of 1995, as part of a new conservation and management initiative, many of the angling proprietors on the river agreed to voluntarily reduce the numbers of early running salmon killed by their fishing tenants. On many beats, angling has ceased in the month of February and from 1 March to the end of June, anglers are restricted to killing a maximum of one spring salmon per rod week (Anon, 1994; DSFIA, 1995). As a result, in 1995, approximately 1186 spring running and early summer salmon were reported to have been returned to the river (Anon, 1994). This catch and release policy has been in operation for three years and by the end of 1997, over 2,500 spring salmon had been reported to have been returned to the river (M. Bruce, pers. com.).

Methods

Salmon Capture and Tagging

Between the 1 March and 8 June 1996, 24 MSW salmon and one grilse (1SW) caught by anglers fishing the Dee were tagged with radio transmitters and then released. The fish were obtained from fishing beats at Park, Crathes Castle and Kineskie near Banchory (26-34 km from the river mouth) and at Sluie and Kincardine/Borrowstone and Carlogie/Ballogie, 13-15.5 km further upstream (Figure 1).

Salmon were hooked and landed with standard fly fishing tackle by anglers following the catch and release guidelines issued by local management interests on the river (see DSFIA, 1995). Handling and tagging procedures were also conducted in accordance with the same guidelines. Fish were brought to the river bank and retained in the water using a large knotless landing net. After a brief inspection of their external condition, each fish was carefully unhooked using long-nosed artery forceps. An intra-gastric radio tag was inserted via the mouth into the fishes' stomach (for details see Hawkins and Smith, 1986). A numbered Floy-tag was then inserted in the basal musculature of the dorsal fin. Sex, body-weight and sea-age were estimated by an experienced biologist in each case. Fish were released immediately after tagging.

The positions of the capture and release points of each of the fish used in the study are shown in Figure 1.

Posters advertising a reward for the return of radio-tags and Floy-tags from recaptured fish were distributed to fishing huts, fishing hotels, fish smokers, salmon agents and local coastal netting interests.

Tracking

Tracking began immediately after tagging and release. Monitoring was achieved using a hand-held receiver (Yaesu FT-290R) and an H-Adcock antenna. Areas of the river's main stem and its tributaries were searched regularly by an experienced radio tracker in a motor vehicle or on foot. Continuous bank side monitoring was also carried out from early March to the end of August using four automatic listening station (ALS) units. ALS units were deployed at selected locations on the river bank of the main stem between Banchory and Ballater to record the passage of radio-tagged fish up or downstream. In late August and mid-December, airborne searches of the whole of the main stem of the river and many of the upper tributaries were conducted from a single engined high winged monoplane equipped with a radio receiver and dipole aerial (for details see Hawkins and Smith, 1986).

Radio-tagged fish were identified by their characteristic radio frequencies and signal pulse rates. The position of each fish was described by Ordinance Survey coordinates which were converted to distances upstream from the river mouth using a digitised map of the river system held on computer. Further details of the tracking procedures and the equipment used are given by Hawkins and Smith (1986).

For the purposes of presentation the fish have been divided into two seasonal tagging groups. The fifteen fish tagged and released in March and April are referred to as "spring" salmon and the ten fish tagged in May and June are referred to either as 'summer' salmon or early grilse.

Behaviour During First 24 Hours After Release

Immediately following tagging and release, radio contact was made with all 25 fish - confirming radio-tag operation.

Three behaviour patterns were recorded over the first 24 hours after release. Two fish dropped downstream soon after being released to a nearby holding pool where they remained for varying periods of time (Fish 8 and Fish 25). Twenty-two fish remained in the same pool where they were released. This group included Fish 9, Fish 10 and Fish 11 which were all released during spate conditions. A single fish, (Fish 6) moved upstream. Contact was temporarily lost with Fish 15 on the day following release at Park on 30 March. However, it was subsequently relocated 39 days later, 5 km further upstream.

The Period From Release to First Sustained Movement Upstream

Three fish moved upstream within less than 48 hours of release (Fish 6, Fish 9 and Fish 17). Among this group the shortest delay was shown by Fish 6 which moved from its release point in the bridge pool at Potarch to a pool 0.9 km upstream less than 24 hours after release. Among the fish tagged in March and April, the average time before the fish moved upstream (> 2km) was 14 days (range <1-64 days). Among the later group, the average period was 24 days (range 2-94 days).

Patterns of Movement Upstream

Progress upstream took place in a stepwise fashion; migratory periods alternating with stationary, quiescent periods. Many of the movements upstream coincided with increases in river flow above the seasonal basal flow or stable or declining flows associated with either snow-melt or rainfall induced spate events. Of the 15 cases where tagged fish were recorded passing ALS units whilst moving upstream, 14 took place between the hours of 2145 and 0304 hours: thereby coinciding with dusk or darkness. The remaining observation was made on 3 March when fish Fish 6 passed a listening station between 1530 and 1545 hours near Potarch bridge coinciding with a snow melt and rainfall induced spate.

During their stationary phase(s) salmon were usually located in the deeper pools favoured by anglers. Among the spring salmon, the most popular stopping points were in the pools on the Glen Tanar and Dinnet beats near Aboyne and at Upper Invercauld near Braemar. Among the summer salmon, pools further downstream at Park, Banchory Lodge, Cairnton, Sluie and Kincardine and Birse were the most frequently used (Figures 1 and 2).

Recaptures by Anglers

Two fish were reported recaptured by anglers fishing on the river. The first fish (Fish 8) was recaptured on the Invery beat at Banchory (Figures 1 and 2) on 11 May - 69 days after being captured at Kineskie, in the first week of March (Table I). The fish was not recorded above the original release point during the intervening period; having dropped back downstream soon after release to the upper pools of the Invery water. Minor relocations were however noted during high water events on the 3 and 4 April. Upon recapture, the fish was killed. The fish was in good condition.

Fish 9 was recaptured on 13 June at Glen Muick near Ballater: 102 days after being tagged and released on the Borrowstone beat near Kincardine O'Neil (Table I; Figures 1 and 2). It was landed by the angler using a knotless landing net, unhooked in the water and released. The fish was detected moving downstream past a ALS units at Glen Tanar on 14 June and at Woodend on the morning of 17 June (0225) where it remained until late August. On 27 August it began to move upstream again passing the ALS at Upper Woodend at 2145 and proceeded upstream to Potarch. It subsequently moved further upstream past Borrowstone to Aboyne and then to Ballater, where it stopped in the Birkhall water until entering the River Gairn on 16 October where it remained over the spawning period. It was last detected in the main river near Banchory on 15 December.

Table 1. Details of adult salmon radio-tagged in the River Dee, 1 March - 8 June (Inclusive)

Fish No	Date tagged	Position	Time	Sex#	Weight (lbs)#	Hooking point	Comments
1	1.3.96	Kincardine	1100	Male	10	Lower Jaw	Fresh run
2	1.3.96	Kincardine	1300	Female	7.5	Lower jaw	LH Pectoral damaged
3	1.3.96	Borrowstone	1715	Female	11	Scissors	Coloured
4	1.3.96	Kincardine	1800	Male	11	Lower Jaw	
5	2.3.96	Borrowstone	0830	Female	7.75	Lower Jaw	Head ulcer, slight bleeding
6	2.3.96	Borrowstone	1340	Female	6.75	Upper Jaw	Fresh run
7	4.3.96	Ballogie	1030	Female	6.75	Lower Jaw	Fresh run
8	4.3.96	L Blackhall	1330	Male	10	Scissors	Damaged fins
9	4.3.96	Borrowstone	1515	Female	6.5	No information*	Abrasions. Scale loss
10	4.3.96	Borrowstone	1745	Female	6.5	Scissors	Ulcer on nose
11	4.3.96	Ballogie	1810	Male	10	No information*	Fresh run
12	23.3.96	Carlogie	1000	Male	11	Lower Jaw	Large wound on flank. Lice marks. Scale loss
13	23.3.96	Ballogie	1720	Female	5.5	Top Jaw	Scale loss
14	27.3.96	Kincardine	1040	Female	8	Lower Jaw	Coloured
15	30.3.96	Park	1100	Female	9	Scissors	Scar on flank
16	25.4.96	U Crathes	1700	Female	14	Scissors	Sea liced
17	6.5.96	U Crathes	1400	Female	10	Lower Jaw	Sea liced
18	6.5.96	U Crathes	1805	Female	8.5	Lower Jaw	Sea liced
19	8.5.96	U Crathes	1245	Female	7	Upper Jaw	Damaged tail
20	20.5.96	Borrowstone	1730	Female	11	Scissors	Lice marked
21	22.5.96	Sluie	0917	Female	5.5	Lower Jaw	
22	22.5.96	Sluie	1630	Female	5.5	Scissors	Coloured
23	1.6.96	Park	1625	Male	14	Upper Jaw	Fresh run
24	7.6.96	Park	1100	Female	8	Scissors	Sea liced. Ulcer on nose.
25	8.6.96	Park	1115	Male	3	Lower Jaw	Sea liced grilse

#Sex and weight estimated
*Hook fell out of fish's mouth when landed

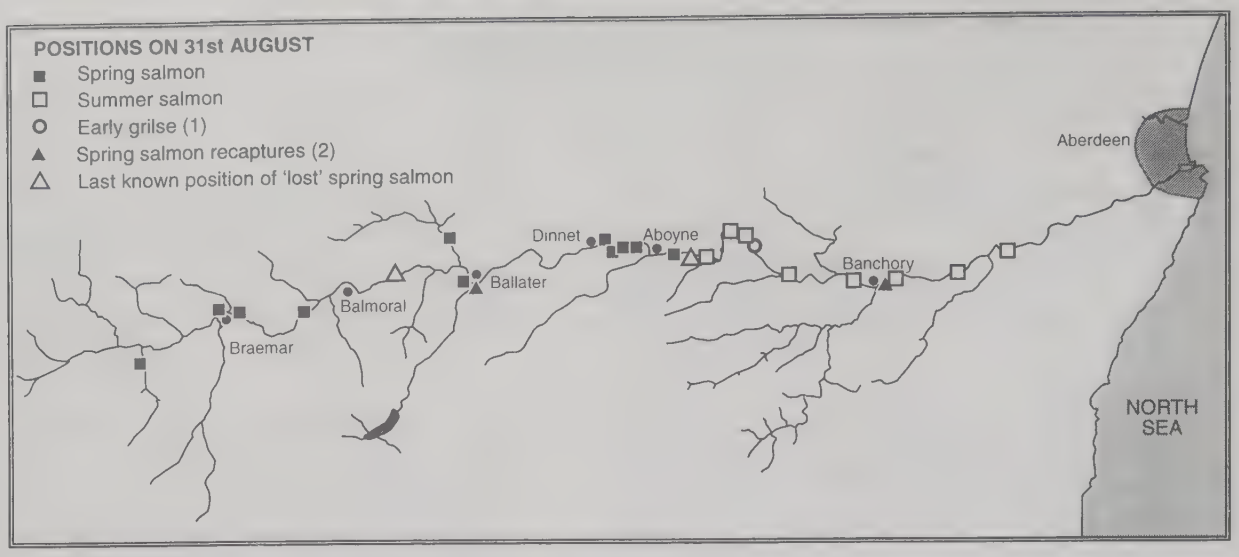

Figure 2.
The pattern of distribution of radio tagged salmon by late summer. The positions at which Fish 8 and Fish 9 were recaptured is also shown (▲) and the last known locations of Fish 4 and Fish 10 (△)

Losses

Three fish were "lost" for periods of one month or more during the course of the study. The first (Fish 4) was tracked from Kincardine O' Neil up to Abergeldie near Ballater, approximately 37km upstream of its release point. It was last located at Abergeldie during a routine survey on 23 May.

The second fish (Fish 10) was last located in the Birse water near Aboyne on 3 June. Neither fish was located again over the remaining period of the study. Fish 2 was last located at Glen Tanar 17 May: 18 days after moving up from the Birse water near Aboyne. However, on 16 October it was subsequently relocated in the junction pool where the River Gairn flows into the Dee near Ballater (Figure 1). It remained there until 1 November when it was located in the lower Gairn near the junction of a smaller spawning tributary approximately 4.5 km upstream of the confluence with the main Dee.

The carcass of Fish 17 was recovered from the river in early June. The fish, (a female; see Table-1), was tagged at the upper Crathes beat on 6 May. Over the next 11 days it moved upstream to Invery and Banchory lodge. By 24 May it had moved up to Cairnton where it remained until 6 June. On 8 June it was recorded by a ALS (situated at Park) moving downstream during the day at 1330 hours. It was subsequently located in a large pool at Lower Durris and removed from the river by a member of the public. Close inspection of the freshly dead carcass indicated the presence of large red furuncles on it's flanks - suggesting the effects of furunculosis, a bacterial disease that is endemic in salmon and trout in the Dee and many other rivers in Scotland.

Pattern of Distribution by Late Summer

Figure 2 shows the distribution of the 20 tagged fish (Fish 2 was not detected at this time) as detected by a catchment-wide aerial survey undertaken on 31 August. All eleven of the remaining 'spring' salmon that were tagged in March and April, were scattered in holding pools within an area just downstream of Aboyne to the very upper reaches of the Dee at Invercauld and the Ey tributary. Particular concentrations of these fish were detected in the pools on the beats between Aboyne and Dinnet and in the Braemar area. In contrast, the nine remaining fish that were released in May and June were distributed throughout the beats from just below Aboyne to below Banchory. None of the later group were detected upstream of Aboyne bridge by this time. However, prior to this date, one fish (Fish 20) had been detected in a pool on the Glen Tanar water for a period of nearly three weeks before dropping back downstream to just below Aboyne on 12 August.

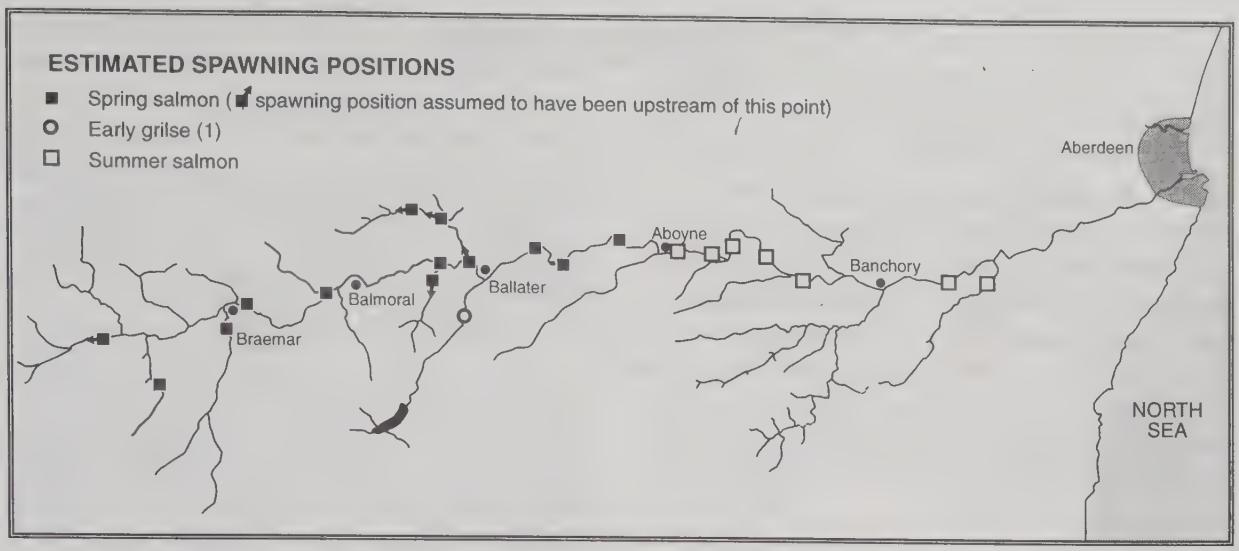

Figure 3.
The pattern of distribution of tagged fish during the spawning season.

Pattern of Distribution and Behaviour At Spawning

Figure 3 shows the distribution of the remaining 21 tagged fish during the spawning season. Spring salmon were widely scattered in the upper reaches of the river and its upper tributaries. Over the course of the spawning period, spring salmon were detected in six of the main spawning tributaries of the upper river; including the upper Dee and the Ey, Fearder and Gairn tributaries. The remaining fish were detected at spawning areas scattered throughout the main stem from Dinnet to Braemar.

In contrast, most of the fish tagged between May and late June remained in the middle and lower reaches of the river during the spawning period. Two fish entered tributaries of the lower river. Fish 24 was tagged just above the Sheeoch burn confluence at Park on 7 June whereupon it dropped 1.1 km downstream. It remained there for the rest of the summer before entering the Sheeoch Burn in early November. It was subsequently recaptured in one of the main spawning areas on the lower Sheeoch during a routine electro-fishing survey, and was found to be in good condition and nearly fully spent.

Fish 18 entered the lower reaches of the Feugh tributary (Figure 1) during a spate on 17 October. It remained in the pools below the falls for approximately 16 days before dropping downstream and back into the main river. At no time was the fish detected above the falls. After leaving the Feugh, the fish remained around the Lower Blackhall and Banchory Lodge area of the main river until mid December where it was presumed to have spawned.

Two fish of the 'summer' group of fish tagged in May and June migrated to spawning positions above Aboyne.

The early grilse tagged at Park in early June (Fish 25; Table I) moved quickly upstream in late October and entered the river Muick tributary near Ballater. It remained in the vicinity of Birkhall House (*ca* 2.5 km upstream of the junction) for 11 days. The fish was not recorded to have reached the falls of Muick 3 km further upstream.

Fish 22, a small, coloured female tagged at Sluie on 22 May (Table I) entered the Girnock burn during a spate on 15 October where it was caught in the adult trap at the FRS research trap facility. Upon capture, the fish was sampled for scales and fork length. No sign of hooking damage in the mouth was detected. The fish was fully mature (ie ovulated) and therefore ready to spawn. Subsequent scale reading revealed that it was a spring salmon.

The detailed movements of three fish were monitored at spawning:

Fish 22 (see above) moved upstream from the Girnock trap shortly after being released. It was subsequently located in a small pool within in the main spawning area of the burn on 6 and 12 November. The fish was presumed to have spawned soon after and then left the burn during a large flood event in late November. It was subsequently located in a large holding pool in the main river near Ballater during an aerial survey on 15 December. On the following day its carcass was removed from the river and found to be fully spent.

Fish 1 (male) entered the lower reaches of the Clunie at Braemar (Figure 1) in mid October. Over the following three weeks it was recorded moving up and downstream over a 2.1 km length of the burn containing numerous spawning fords between the outskirts of Braemar upstream to the junction with the Callater burn. The fish was found dead in a pool just upstream of Braemar on 21 December and was fully spent.

Fish 16 (female; Table I) moved upstream from its summer holding position at Sluie to the Mill of Dess (Figure. 1). Between 15 and 18 December it was located on two large spawning fords just situated above Dess. On 21 December it had moved back downstream to a large pool near Kincardine O'Neil (Figure 1).

Four other tagged fish (F23, F20, F11 and F12) were detected at well known spawning fords in the main river at Lower Crathes, Aboyne, Cambus O'May, Polhollick and the mouth of the Fearder respectively (Figures 1 and 3). The carcass of Fish 20 (female) was found stranded on a shingle bank *ca* 4.5 km below Aboyne in early January. It was fully spent.

Discussion

In this study, 21 (84%) of the 25 fish that were radio-tagged and released back into the Dee survived to spawning time. Furthermore, all of the fish that were monitored continued their upstream migration to spawning and juvenile rearing areas of the main river or tributary streams. These observations suggest that the fitness of most of the fish captured and returned to the river was not significantly impaired. Within each sea-age class of adults, fish tagged earlier in the season migrated to spawning areas further upstream than those tagged later in the year. The findings of the present study therefore accord with the results of similar catch and release studies using radio-tagging on the Dee in 1995 (Webb, 1995b), the Little Gruinard in Western Scotland (Walker and Walker, 1991) and on the Ponoi river on the Kola peninsula in Northern Russia (NASCO, 1994).

Compared with many previous radio tracking studies conducted on the Dee, the individual behaviours of most of the tagged fish used in this investigation were not monitored intensively. Nevertheless, the patterns of movement of catch and released salmon tended to broadly conform to many previously published observations of adult salmon behaviour in the river (Hawkins and Smith, 1986; Laughton and Smith 1992). Specifically, movements upstream within the main-stem were often associated with the hours of darkness and spate events. Periods of inactivity were spent in recognised holding pools scattered along the river (Hawkins and Smith, 1986; Laughton and Smith, 1992). Similarly, where recorded, behaviours at spawning were broadly consistent with previously published observations (Hawkins and Smith, 1986; Webb and Hawkins, 1989) suggesting that the fish behaved normally during the spawning period.

Among most of the fish released, little or no sustained movement was recorded downstream from the original release site. In a few cases, significant downstream movements were observed. However, with only one exception each fish either resumed movement upstream at a later date or subsequently entered a tributary in the locality. Behaviour of this kind has been reported previously at various stages of riverine migration (Milner, 1990) and particularly in the vicinity of tributary confluence areas (see, Webb, 1990; Laughton, 1991). Furthermore, movements downstream by fish released by anglers have been previously recorded among fish released during high water conditions at which time fish may move downstream to larger pools (Webb, 1995a). Larger movements downstream over tens of kilometres have also been associated with the effects of disease or physical damage (Webb, 1990) or movement into other rivers (Laughton, 1991; G. Smith, pers. com.).

Two of the fish caught and released in this study were subsequently reported to have been recaptured by anglers - corresponding to an overall recapture rate of 8%. This observation accords with the results of a more extensive study conducted over the same period where 210 fish were Floy-tagged by ghillies and released back into the river. Subsequent recaptures amounted to a rate of less than 5% (DDSFB, 1996). Evidently, the findings of these concurrent studies were significantly lower than previously recorded in the river during similar although a smaller radio tracking study conducted in 1995 - when three of the six fish released were recaptured by anglers before the end of June (Webb, 1995b). The reasons for the great disparity between the findings of these three studies are not known but may be reflection of the sample sizes used or river conditions pertaining at the time. The results of the research carried out in 1996 were broadly consistent with 2 SW salmon recapture rates recorded during tagging studies carried out on the Dee and elsewhere where levels ranged from approximately 5-20% (Shearer, 1992; Laughton and Smith, 1992; Davidson *et al*, 1997).

On balance, the results of this study suggest that fish returned to rivers by anglers are not necessarily more susceptible to recapture by anglers than fish tagged in the normal way. Indeed, fish returned to the river may be less prone to exploitation than those available for first capture.

During this study one fish was recorded to have died before spawning. However, this level of mortality is well within the range of losses reported during previous radio tracking programmes of the Dee and elsewhere where fish were captured by netting or trapping. Indeed, the loss of only one of the 25 fish used in this project is well within accepted loss limits set by fishery managers.

Conclusions

The results of this study suggest that, if treated with care, most fresh-run and early summer salmon returned to the river by anglers behave normally and survive to spawn. Catch and release can be considered as an effective conservation measure.

References

Anon. 1994. *Dee Newsletter*, **3**, 8pp.

Anon. 1997. Spring salmon: Tweed launches new five year conservation programme. *The Tweed Foundation Newsletter*, **13**, 8pp

Davidson, I.C., Cove, R.J. and Milner, N.J. 1997. *Dee Stock Assessment Programme:annual report 1995.* Cardiff: Environment Agency, 51pp.

[DDSFB] Dee District Salmon Fishery Board. 1996. *Dee District Salmon Fishery Board annual report 1996.* Aberdeen: Dee District Salmon Fishery Board, 38pp.

[DSFIA] Dee Salmon Fishing Improvement Association and Dee District Salmon Fishery Board. 1994. *Salmon rod fishing, River Dee, Grampian.* Final Report. Aberdeen: Grampian Enterprise, 75pp.

[DSFIA] Dee Salmon Fishing Improvement Association. 1995. *The Dee. Its future is in your hands.* [Advisory leaflet]. Aberdeen: Dee Salmon Fishing Improvement Association, 1pp.

Hawkins, A.D. and Smith, G.W. 1986. Radio-tracking observations on Atlantic salmon ascending the Aberdeenshire Dee. *Scottish Fisheries Research Report*, **30**, 24pp.

Laughton, R. 1991. The movements of adult Atlantic salmon (*Salmo salar* L.) in the River Spey as determined by radio telemetry during 1988 and 1989. *Scottish Fisheries Research Report,* **50**, 35pp.

Laughton, R. and Smith, G.W. 1992. The relationship between the date of river entry and estimated spawning position of adult Atlantic salmon (*Salmo salar* L.) in two major Scottish east coast rivers. In: Priede, I.G. and Swift, S.M. (eds). *Wildlife telemetry: remote monitoring and tracking of animals.* New York: Ellis Horwood, 423-433.

McLaren, I.S., Donaghy, M.J. and Hay, D.W. 1996. Survey of the juvenile salmon populations in the western Dee catchment, 26 July - 9 August 1996. Report for the Dee District Salmon Fishery Board, 4pp.

Menzies, W.J.M. 1921. Salmon investigations in Scotland, 1921. I. Salmon of the River Dee (Aberdeenshire). *Salmon Fisheries, Fishery Board for Scotland,* **I**, 48pp.

Menzies, W.J.M. and Macfarlane, P.R.C. 1924. Salmon investigations in Scotland, 1922. II. Salmon of the River Dee (Aberdeenshire). *Salmon Fisheries, Fishery Board for Scotland,* **III**, 52pp.

Menzies, W.J.M. and Macfarlane, P.R.C. 1931. Salmon of the River Dee (Aberdeen) in 1925. *Salmon Fisheries, Fishery Board for Scotland,* **IV**, 22pp.

Milner, N.J.(ed.). 1990. *Fish movement in relation to freshwater flow and quality. Workshop proceedings, University of Bristol, 4-6 April 1989.* Pitlochry: Atlantic Salmon Trust and Wessex Water, 51pp.

NASCO. 1994. Catch and release. *NASCO Council Report,* CNL(94)31, 8pp.

[NRA] National Rivers Authority. 1995. *Catch and release: a guide to careful salmon handling.* [Leaflet]. Bristol: National Rivers Authority, 1pp.

[SAC] Salmon Advisory Committee. 1994. *Run timing in salmon.* London: MAFF Publications, 55pp.

[SOAEFD] Scottish Office Agriculture, Environment and Fisheries Department. 1996. *Sea trout conservation in the West Highlands.* (SOAEFD guidance notes leaflet). Pitlochry: Scottish Office Agriculture, Environment and Fisheries Department, Freshwater Fisheries Laboratory, 1pp.

[SSSTF] Scottish Salmon Strategy Task Force. 1997. *Report of the Scottish Salmon Strategy Task Force.* Edinburgh: The Scottish Office, 86pp.

Shearer, W.M. 1985. Salmon catch statistics for the River Dee, 1952-83. In: Jenkins, D. (ed.). *The biology and management of the River Dee.* (ITE Symposium Series, 14). Huntingdon: Institute of Terrestrial Ecology, 127-141.

Shearer, W.M. 1992. *The Atlantic salmon, natural history, exploitation and future management.* Oxford: Fishing News Books, 244pp.

Waddington, R. 1947. Salmon fishing: a new philosophy. Peter Davis: London, 199pp.

Walker, A.F. and Walker, A.M. 1991. The Little Gruinard salmon catch and release experiment. *Scottish Fisheries Research Services Report,* **2/91**, 10pp.

Warren, J.S. 1985. Hydrology of the River Dee and its tributaries. In: Jenkins, D. (ed.). *The biology and management of the River Dee.* (ITE Symposium Series, 14). Huntingdon: Institute of Terrestrial Ecology, 23-28.

Webb, J.H. 1990. The behaviour of adult Atlantic salmon ascending the Rivers Tay and Tummel to Pitlochry dam. *Scottish Fisheries Research Report, **48***, 27pp.

Webb, J.H. 1995a. Adult salmon in the River Dee: patterns of migration, distribution and spawning. In: Aberdeen Research Consortium and Salmon Fishing Improvement Association. *Salmon in the Dee catchment: the scientific basis for management. Proceedings of a one-day meeting held at Glen Tanar House, 13 October 1994.* Pitlochry: Atlantic Salmon Trust, 9-20.

Webb, J.H. 1995b. *The Aberdeenshire Dee: catch and release.* Progress report (including audited accounts), December 1995. Pitlochry: Atlantic Salmon Trust, 44-47.

Webb, J.H., and Hawkins, A.D. 1989. The movements and spawning behaviour of adult salmon in the Girnock Burn, a tributary of the Aberdeenshire Dee, 1986. *Scottish Fisheries Research Report,* **40**, 41pp.

Youngson, A.F. 1995. *Spring salmon.* Pitlochry: Atlantic Salmon Trust, 52pp.

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